Cyclesonde – Automatic Profiler Observations to Support Acoustic Objectives

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LONG-TERM OBJECTIVES

We are planning to develop an all-electric autonomous vertical profiler for long-term surveillance. The first goal is to develop a all-electric vertical profiler to support acoustic objectives in acoustic observatory settings with power delivered from shore via submarine cable and signals communicated in real time by fiber optic cable. This profiler will remain roller coupled to reduce wave-induced sensor noise and be self-ballasting to ease installation and functional reliably in stronger currents.

The second goal is a smart power docking mechanism, which will be developed to reliably transfer power from the cable system to the autonomous profiler to recharge onboard battery systems. Higher power sensors and systems, which have been impractical for Cyclesonde operation and now much longer missions will be practical. This power docking mechanism could be useful to other autonomous vehicles and could function as an ROV installable connection system for deep and/or hostile waters.

The third and longest-range goal is a miniaturized, air deployable, all-electric profiler, which can stand-alone for prolonged periods of time and report on command by radio. Such profilers could be deployed in a free drifting or moored coastal ocean configurations.

OBJECTIVES

Our short-term objective is to support acoustic modem testing at SFOMC with real time temperature, electrical conductivity and ocean current profiles. These data are to be transmitted from the Cyclesonde profiler by inductive coupling through the mooring wire and thence by interface to the Navy MUX and lastly to shore by fiber optical cable.

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14. ABSTRACT
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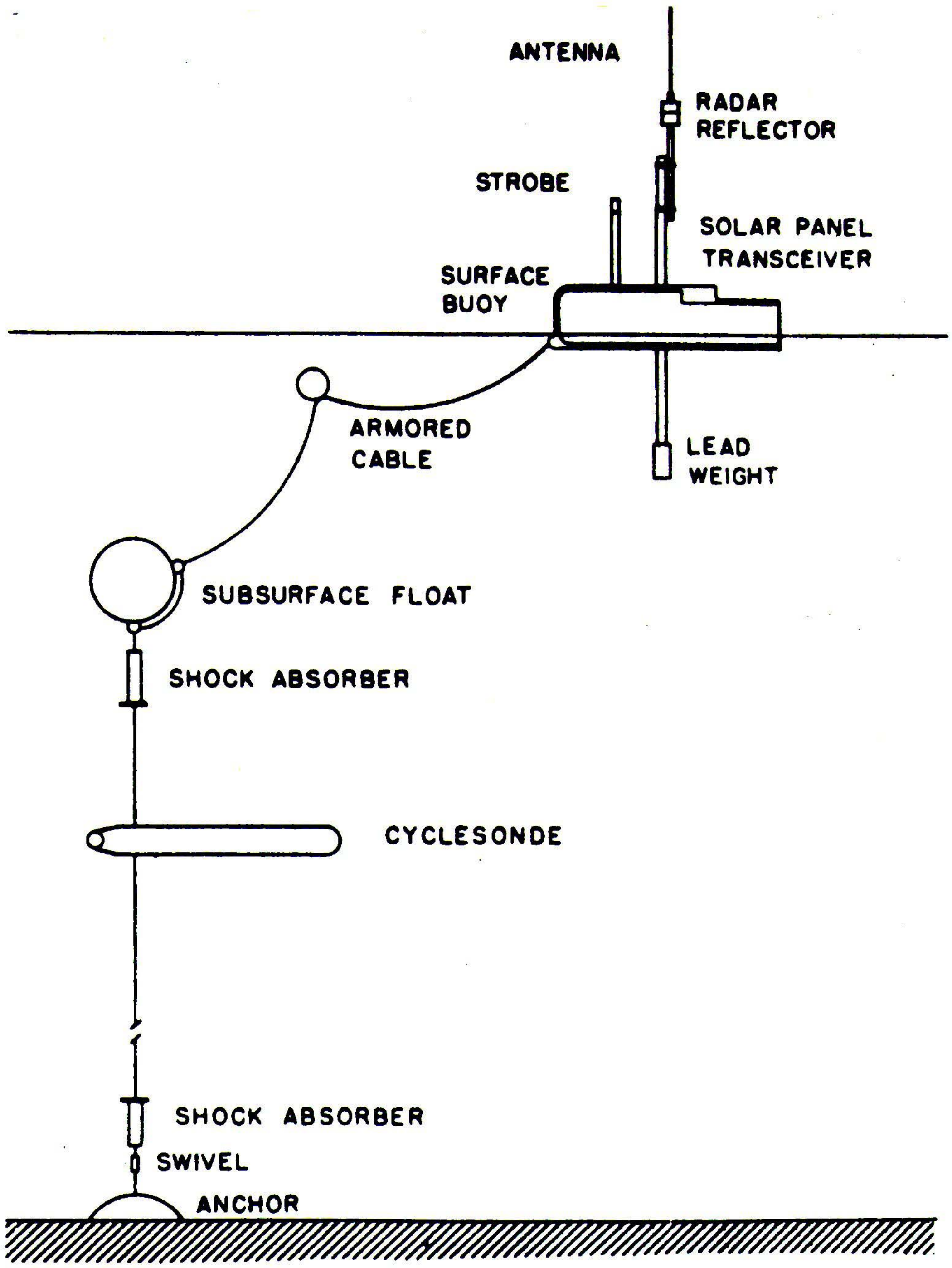

Figure 1: A Complete Cyclesonde Mooring for Coastal Acoustics/Oceanography.
The above mooring was set up for radio telemetry of data/commands. The configuration in use at SFOMC has an interface housing at the base of the mooring, which converts the Cyclesonde bi-phase L format to a Navy MUX compatible RS422 format for transmission ashore via fiber-optic cable.

APPROACH

In the coastal ocean, at SFOMC, we have used a moored Cyclesonde automatic profiler as shown moored schematically in Figure 1 and the Cyclesonde vehicle is seen in the photograph on the quad chart. The instrument profiles between depth limits set by the stops on a taught wire mooring. Mechanical connection with the mooring wire is maintained with a very low friction, three sheave roller block. An inductive coupler mounted within the roller block induces data signals coded in bi-phase L format to send data to a receiving toroid either near the top or bottom of the mooring for radio or fiber optic transmission respectively. A 28" (submarine net float) steel sphere provides buoyancy and a 660 lb. lead anchor on the bottom keep the mooring taught and nearly vertical. For deeper water and stronger currents, a larger subsurface float and a heavier anchor will be required.

On a fixed schedule, the displacement of the Mk III Cyclesonde in increased above neutral buoyancy by inflating a bladder with helium. At a later scheduled time, helium is exhausted from the bladder making audible noise and releasing a small bubble cloud into the ocean. Each profile cycle reduces the weight of helium aboard. Thus the Mk III Cyclesonde must be very precisely ballasted in order to profile reliably for periods of a month or more. In areas of strong currents, like the Florida Straits, the margin of ballasting error is further reduced by the increased friction on the wire caused by drag acting on the profiler and the increased wire angle of the mooring.

In the future all-electric Mk IV version of the Cyclesonde, the displacement will be increased by pumping oil into an external bladder with an electric pump using energy stored in an onboard battery which is recharged by the power docking system each time the profiler reaches the bottom of the mooring. Using data from the current, pressure and pitch sensors, the onboard computer will control the electronically variable ballasting system. Such a system will make it possible for less skilled personnel to install a Cyclesonde mooring since there is no weight loss, it will do its own ballasting calculations and it will thus automatically adjust to stronger currents.

The prototype Mk IV Cyclesonde electronics, which we are presently operating in the MKII Cyclesonde, includes a microprocessor control and data sampling/recording system for increased data sampling flexibility and much greater nonvolatile onboard data storage capacity. Dr. Hein Nguyen designed the electronic interface hardware and software, which has enabled the Onset Model 8 recorder/controller engine to communicate with the standard Cyclesonde Mk III sensors/systems. Another wire mounted housing at the base of the mooring allows inductively coupled signals from the mooring to communicate with the MUX/fiber optic/power cable systems. Cyclesonde testing has demonstrated the first successful use of the Mk IV electronics including the telemetry of data from the mooring cable to the MUX via RS422 interfaced and thence through 4.26 km. of fiber optic cable to shore. The MUX system provides a GFI protected 52 VDC power supply for the RS422 interface. Mr. Raul Murciano of R & R Electronics built and installed the electronic interface boards designed by Dr. Nguyen. This same combination of electronics personnel have provided practically all of the electronic hardware used by Dr. DeFerrari in his various acoustic projects at RSMAS over more than 20 years. Dr. John Van Leer is responsible for all mechanical aspects of design, construction and deployment based upon 32 of autonomous profiler experience as described in the appendix.

WORK COMPLETED

The Cyclesonde automatic profiler experiment as proposed this year for SFOMC is designed to support acoustic modem testing with real time profiles of temperature, electrical conductivity and current

velocity. What depth should a modem receiver be mounted? It probably depends on the AUV mounted source depth and the sound velocity profile. In shallow water, multi-path and scattering issues may dictate the proper depth. In deeper water applications, there may be optimum depths at which acoustic signals from an AUV modem will be strongest for a given sound velocity profile. With electronically variable ballasting, one could hover at the optimum depth for strongest signal or hunt vertically by using small amplitude profiles in flight.

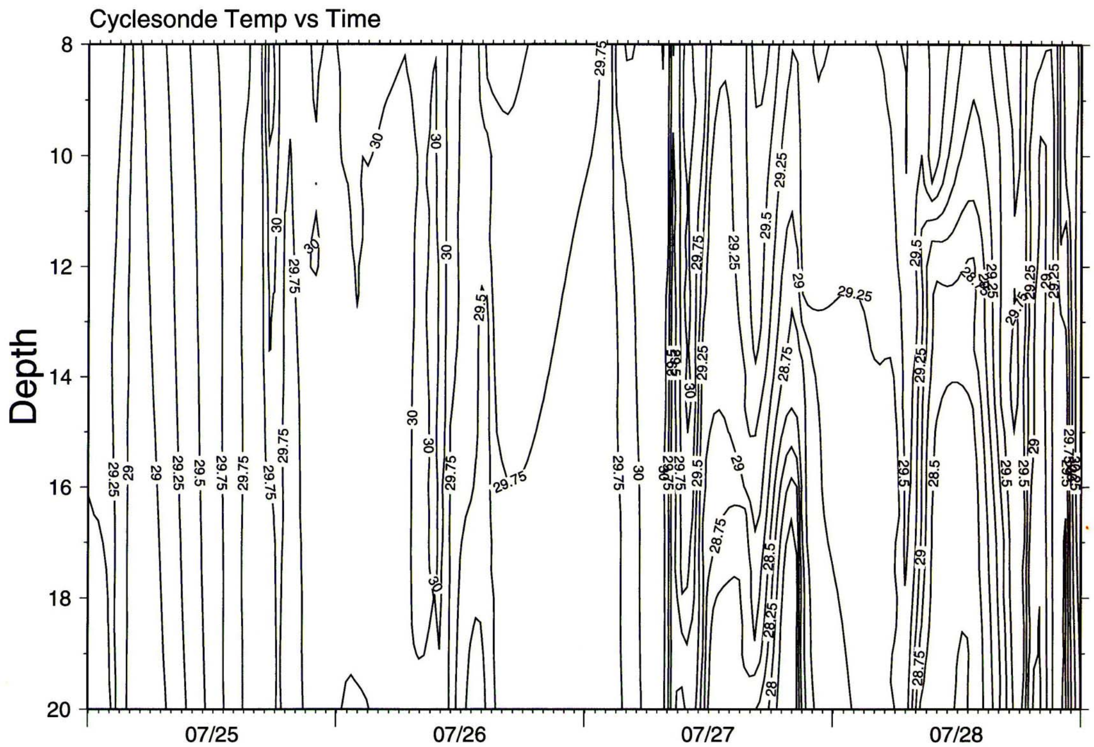

Figure 2: Temperature (Deg. C) as a Function of Time (Days) and Depth (Meters)

RESULTS

A time vs. depth diagram of temperature structure during four days in July is seen in Figure 2. These temperature fluctuations correlate with passing eddy signals as seen in the velocity structure during the same period with low temperature pulses corresponding to onshore flow on the leading edge of the eddy. Data of this type will be regularly forwarded to Dr. Pierre-Philippe Beaujean of FAU, so that he may use it in his acoustic propagation calculations in his acoustic modem tests. Our profile timing will be adjusted to match his measurement periods with an up profile immediately before and a downward profile immediately after each of his test intervals. When a dummy acoustic modem becomes available, we will mount it on the Cyclesonde and generate repeated profiles from a known signal source to check variations in transmission conditions with depth.

Sensor calibrations were completed in early summer 2003. However, the data is to be delivered ashore by fiber optic cable through the MUX system, as successfully demonstrated during its first year of operation. The MUX system has experienced difficulties during its first deployment this year. A redesign/rebuild effort is currently underway this summer with redeployment scheduled for late September 2003. Launch of the Cyclesonde mooring will follow the successful deployment of the

MUX using the no cost extension granted by the Navy to accommodate this delay. Cyclesondes are capable of reporting by radio telemetry as shown in Figure 1, however, no provision for radio telemetry were made to accommodate the extra hardware and salary needed to support radio telemetry in this years budget.